

Coupling Coordination or Spatial Mismatch? A GIS-Based Study on the Suitability Evaluation and Optimization Strategies of County-Level Tourism Development - A Case Study of Panzhou City

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Abstract: This study conducts tourism suitability evaluation and GAP analysis for Panzhou City in Guizhou Province - located at the junction of Yunnan, Guizhou, and Guangxi - using GIS technology. Panzhou City is rich in natural and cultural landscapes, which has a superior foundation for tourism development, DEM data of geospatial data cloud platform, land use status data from Panzhou Natural Resources Bureau, transportation network data of transportation department and Baidu map, etc. After preprocessing with ArcGIS software, natural environment (including elevation, slope, aspect), ecological sensitivity (distance from water source, vegetation coverage), socio-economic potential (distance from town center, population density), and infrastructure (including toll stations, transportation facilities, roads, etc) are selected according to tourism, ecology and geography to construct an evaluation system, and divided into 5 suitability levels. The results show that the tourism suitability of Panzhou City presents a distribution pattern lower in the north and higher in the south, high suitability in core scenic areas and low in remote mountainous areas. GAP analysis shows that tourism development is unbalanced, convenient transportation areas are well-developed, remote mountainous areas lag behind, and there are problems in the layout of transportation, accommodation and catering facilities. Based on this, this paper puts forward some strategies, such as regional development, route optimization, product diversification, resource protection and integration, and service facilities upgrading.

Keywords: GAP analysis; GIS; Panzhou City; tourism development strategy; tourism suitability evaluation

1 INTRODUCTION

Panzhou City, Guizhou Province, located at the junction of Yunnan, Guizhou and Guangxi Provinces, is known as the "throat of Yunnan and Guizhou" and has a unique geographical position. Its domestic tourism resources are rich and diverse, covering natural and cultural landscapes. In terms of natural landscape, there are provincial-level scenic spots such as Dadong Bamboo Sea, Ancient Ginkgo biloba and Slope Grassland, with beautiful mountains and rivers, pleasant climate and forest coverage rate of 31.1%. It belongs to subtropical plateau monsoon climate zone, with an average annual rainfall of more than 1400 mm and an average annual temperature of 15.2 °C. It has the characteristics of cool capital, is suitable for the growth of various animals and plants, and provides high-quality conditions for eco-tourism and leisure vacation. The cultural landscape is also splendid. There are ancient human civilization sites-PanxianDadong, a national key cultural relics protection unit, and Panxian Conference Site, a patriotic education base in Guizhou Province. Ethnic festivals such as Yi Torch Festival, Hui Eid al-Adha Festival and Buyi Song Festival are splendid and have profound national culture, which is very attractive to tourists.

Geographic Information System (GIS), as a technology integrating geospatial data collection, storage, management, analysis and display, has unique advantages in the field of tourism research [1]. It can integrate the complex and diverse tourism resources information in Panzhou City, and visually present the spatial distribution characteristics of resources. With the help of spatial analysis function of GIS, such as superposition analysis, we can explore the relationship among terrain, traffic and tourism resources, and network analysis can optimize tourism traffic route planning, thus providing scientific and accurate decision-making basis for tourism planning. Through visual expression, boring data can be transformed into clear and easy-to-understand maps and charts, which can be seen at a glance whether tourism management departments formulate policies or tourists plan trips,

greatly improving the efficiency and scientificity of tourism resources management [4].

However, existing GIS-based tourism suitability evaluations mostly stop at identifying "where is suitable" by establishing an indicator system to classify suitable, moderately suitable, or unsuitable areas. Although such studies can provide a macro reference for tourism development planning, they have two key limitations: (1) they fail to further diagnose "which suitable areas have been effectively developed and which remain undeveloped or underutilized"; and (2) they lack a systematic method to quantify the gap between suitability and actual development status, so planning recommendations often remains at the level of potential identification and cannot directly guide precise resource allocation or investment prioritization.

Therefore, on the basis of traditional tourism suitability evaluation, this study innovatively introduces GAP analysis [7, 8] to form a coupled analytical framework of "suitability evaluation + GAP analysis". The core innovation of this study is that it not only answers "where is suitable for development", but also further answers "among the suitable areas, where are the development gaps or mismatches between supply and demand", thereby extending tourism potential evaluation to the level of matching resource development with market demand. The unique value of GAP analysis lies in three aspects: (1) by overlaying suitability evaluation results with the spatial distribution of existing tourism facilities/attractions, it quantitatively identifies "high-suitability but undeveloped" areas, providing precise targets for incremental tourism project placement; (2) by integrating tourism market demand (e.g., tourist preferences, source market radiation scope), it identifies gaps where "demand exists but supply is absent or insufficient", guiding tourism product innovation and market expansion; (3) by linking GAP analysis results with constraints such as ecologically sensitive areas and transportation accessibility, it avoids blind development and achieves optimal allocation of tourism resources and sustainable utilization.

For tourism development in Panzhou, tourism suitability evaluation and GAP analysis based on GIS are of far-reaching significance. On the one hand, accurate tourism suitability evaluation can clarify the potential and limiting factors of tourism development in different regions, which is helpful to rationally arrange tourism projects, avoid blind development, realize the optimal allocation of tourism resources and promote the sustainable development of tourism [3]. For example, by analyzing ecologically sensitive areas, we can protect the fragile ecological environment and guide tourism development to concentrate in suitable areas. On the other hand, GAP analysis can find out the gap between tourism resources development and market demand [4], find "blank" areas that have not been fully developed or tourists' demand has not been met, point out the direction for tourism product innovation and tourism market expansion, further enhance the competitiveness of tourism in Panzhou, promote local economic development, help rural revitalization, and effectively transform Panzhou's unique tourism resources advantages into economic development advantages.

2 STUDY AREA

Panzhou City (Fig. 1) is located in the west of Guizhou Province and the southwest of Liupanshui City, with terrain high in the northwest and low in the southeast. The territory is mountainous, with plateau and mountain landform, such as Wumeng prairie. The climate is mild, with an average annual temperature of 15.2 °C, which is suitable for the growth of animals and plants and provides a basis for ecotourism.

Panzhou is rich in mineral resources, especially coal resources, with large reserves and excellent quality. Among the land resources, mountainous land accounts for 82.4%, land suitable for forestry and animal husbandry accounts for 61.3%, and cultivated land accounts for 23.9%. The forest coverage rate is 62.66%, and there are many nature reserves and forest parks, which are suitable for developing forest health tourism projects.

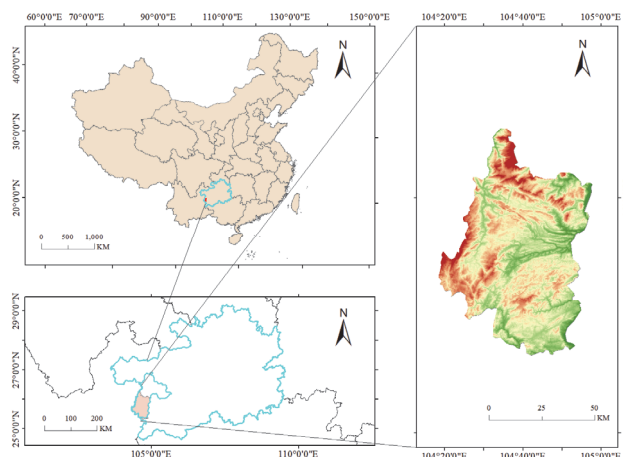


Figure 1 Panzhou City Region

Panzhou City has jurisdiction over many towns and streets, with a total area of 4056 square kilometers and a resident population of 1069300. It is an important transportation, energy, commerce, logistics and tourism node connecting Yunnan Province and Guizhou Province. In 2022, the regional GDP will reach 66.084 billion yuan, and the ratio of three industrial structures will be 11.9: 52.3: 35.8. (Data source: Statistical Bulletin of National

Economic and Social Development of Panzhou City in 2022) The transportation is convenient, including Shanghai-Kunming High-speed Railway, Shanghai-Kunming Expressway and other trunk lines, and the city's highway network is well-developed. Panzhou City has profound cultural heritage, including ancient human cultural sites and Xinmin ichthyosaur fossil sites. It is home to many national intangible cultural heritages and four AAAA-level tourist attractions. In recent years, the government has increased tourism investment, improved tourism reception capacity, strengthened publicity and promotion, and attracted tourists [13].

Panzhou is rich in tourism resources, including natural landscape and human history. In terms of natural landscape, it has the reputation of the hometown of ancient ginkgo in the world, and the ginkgo leaves are golden in autumn; Full of Green in Dadong Bamboo Sea Scenic Area; Wumeng Prairie is vast, attracting tourists to experience grassland culture. In terms of cultural landscape, Panxian Conference Site and Dadong Site are important places for historical research, while Yi Torch Festival is a well-known activity to experience ethnic customs [15, 16[15]. The tourism resources of Panzhou City provide a solid foundation for its tourism development. The region has the potential to create diversified tourism products, design diversified tourism routes and experience projects, meet the needs of different tourists, attract tourists and promote the prosperity of local tourism.

2 DATA SOURCE AND PROCESSING

2.1 Data Sources

In terms of geographic data, this study obtained the high-resolution digital elevation model (DEM) [17] data of Panzhou City, which originated from the geospatial data cloud platform (<https://www.gscloud.cn/search>), and its resolution is accurate to 30 meters, which can accurately reflect the topography and geomorphology characteristics of Panzhou City, such as the ups and downs of mountains, hills, valleys and other landforms, providing a basis for the analysis of topography and geomorphology related indicators. The data of land use status comes from Panzhou Natural Resources Bureau combined with geographical monitoring cloud platform (<http://www.dsac.cn/DataProduct/Index/10>). Based on the latest land survey results, various land use types such as construction land, agricultural land, forest land and water area are divided in detail, and the land function attributes of each region are clarified to help the spatial layout research of tourism development. Traffic network data combines highway and railway vector data provided by Guizhou Provincial Communications Department, real-time traffic condition information of Baidu map open platform and POI data platform (<https://www.poi86.com/>), covering national highway, provincial highway, county road, rural road and railway line layout.

2.2 Research Methodology

2.2.1 Research Methods and Technical Routes

In the process of data processing, ArcGIS software is used to preprocess geographic data. According to DEM data, topographic factors such as elevation, slope and aspect are extracted by spatial analysis tools, and corresponding thematic layers are generated according to

established grading standards [19]. After format conversion and coordinate registration of land use status data, reclassify according to research needs, and highlight the distribution of land use types closely related to tourism development. Traffic network data are vectorized, topological relations are constructed, and different traffic cost attributes are assigned based on road information for subsequent network analysis.

In this study, a variety of research methods are comprehensively used to ensure the scientificity and comprehensiveness of the research. Firstly, the spatial database is constructed by using GIS technology, integrating multi-source data such as topography, land use, transportation and tourism resources in Panzhou City, and exploring the influence of different elements on tourism suitability by means of spatial analysis such as superposition analysis and buffer zone analysis, so as to visually present the spatial distribution pattern of tourism resources and its relationship with the surrounding environment. Referring to relevant policy documents, academic documents, statistical yearbooks and other materials, this paper combs the policy background, previous research results and socio-economic data of tourism development in Panzhou City, providing theoretical support and macro background analysis for the research.

Adopt weighted comprehensive evaluation formula to calculate the comprehensive score. S is the comprehensive score of tourism suitability, W_i is the I index weight, and X_i is the standardized index value. According to the score, the tourism suitability grade of Panzhou City is divided.

$$S = \sum_{i=1}^n W_i X_i \quad (1)$$

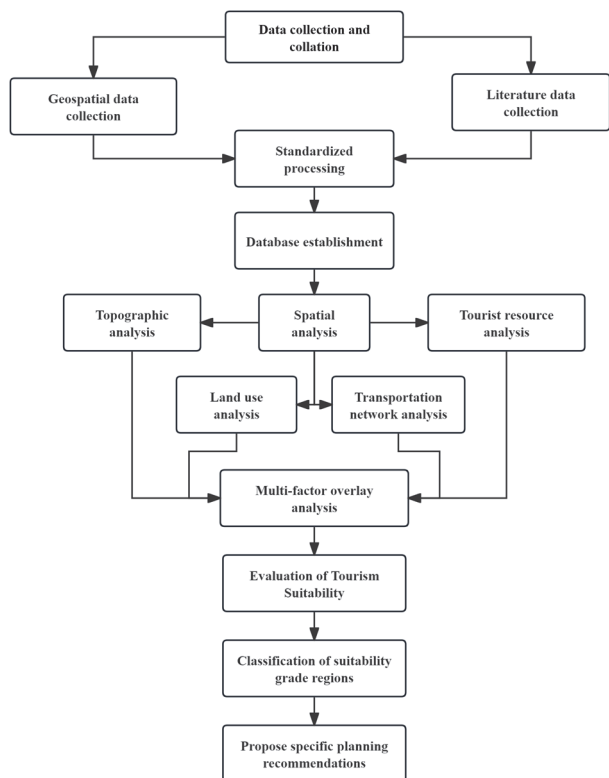


Figure 2 Technology roadmap

The technical route follows the following processes: first, data collection and collation, obtaining the required information from geospatial data, literature data and other channels, and carrying out standardized processing to establish a database, then, using GIS software to carry out spatial analysis, carry out single element analysis such as topography, land use, transportation network and tourism resources, and on this basis, implement multi-element superposition analysis to evaluate tourism suitability and divide suitable grade areas [20]. Finally, according to the above analysis, this paper puts forward targeted planning suggestions for tourism development in Panzhou City.

The technology roadmap is as follows (Fig. 2).

2.2.2 Selection and Quantification of Evaluation Index

When selecting tourism suitability evaluation indicators, we should strictly follow the multidisciplinary theories such as tourism, ecology and geography, to ensure that the selected indicators can accurately reflect the essential characteristics of tourism development in Panzhou City. For example, according to the ecological principle, the ecological sensitivity index is introduced to measure the tolerance of regional ecosystem to tourism development activities. By analyzing specific factors such as vegetation coverage, soil type and soil erosion sensitivity, it is scientifically determined which areas are suitable for large-scale tourism development and which areas need to limit the development intensity to avoid irreversible damage to the ecological environment [21].

Systematic principle emphasizes that from a holistic perspective, it comprehensively covers all kinds of factors affecting the tourism suitability of Panzhou City. It not only includes natural environment subsystems, such as topography and geomorphology (elevation, slope and aspect affect the layout and construction difficulty of tourism projects, high mountain areas are suitable for exploration and viewing projects, and gentle slope areas are conducive to the construction of leisure and holiday facilities) [22]. It also involves social and economic subsystems, such as traffic convenience (layout and accessibility of roads, railways and aviation lines, high-speed railway station and high-speed intersections near scenic spots can improve tourist visit rate), which are interrelated and interact to form a complete tourism suitability evaluation system, which fully reflects the comprehensive conditions of tourism development in Panzhou City.

The operability principle pays attention to the accessibility of index data and the practicality of evaluation methods. In terms of data acquisition, the selected indicators rely on existing statistical data, geographic information data and field research results as much as possible. For example, land use type data can be directly extracted from the land use status map obtained by the land department, and the distribution of construction land, agricultural land and ecological land can be clearly defined, providing intuitive reference for the spatial layout of tourism development [23].

Based on the above principles, this study selects four first-class indicators: natural environment, ecological sensitivity, socio-economic potential and infrastructure, and constructs the evaluation index system of tourism

suitability in Panzhou City. Natural environment indicators cover topography and geomorphology. Three secondary indicators [24] are selected for topography and geomorphology. Ecological sensitivity selects vegetation coverage rate and distance from water source as two secondary indicators [25]. Social and economic potential is selected as two secondary indicators: distance from town center and population density [26]. Infrastructure indicators focus on traffic convenience, which comprehensively considers the accessibility of roads, railways and aviation, and selects three secondary indicators [27] of toll stations, traffic facilities and roads (Fig. 3). See Tab. 1 for a description of specific indicators.

Table 1 Tourism suitability evaluation index system

First-class index	Secondary index	Reasons and explanation of index selection
Natural environment	Elevation	Elevation will affect the difficulty and cost of development, and high elevation, low temperature, low oxygen content in air, low comfort and low safety.
	Slope	The steeper the slope is, the more unfavorable it is to plant growth, and it is not easy to recover after destruction, and it is not suitable for human activities.
	Slope aspect	The slope aspect is related to the amount of illumination. Illumination is sufficient in the southern direction and flat areas, while the illumination in the north and other directions is relatively less, which has a great influence on the plant richness.
Ecological sensitivity	Vegetation coverage	Reflecting the stability of regional ecosystem, the higher the vegetation coverage, the lower the ecological sensitivity, and the more suitable for tourism development.
	Distance from water source	The closer to the water source, the lower the construction and operation cost of tourism facilities, but it is necessary to control the development intensity to protect the water source environment.
Socio-economic potential	Distance from town center	The closer to the town, the stronger the sharing of infrastructure and the lower the cost of tourism development.
	Population density	Reflecting the potential of the surrounding market, the higher the population density, the stronger the demand for short-distance tourism.
Infrastructure	Toll station	The traffic near the toll station is convenient, the flow of people is large, and the supporting facilities are more perfect.
	Transportation facilities	The more perfect the transportation facilities, the higher the accessibility of transportation.
	roads	Roads directly affect whether tourists can reach scenic spots smoothly and affect tourists' experience.

According to relevant standards and reference classification methods, tourism suitability is divided into five grades: 5 high suitability, 4 high suitability, 3 medium suitability, 2 low suitability and 1 low suitability. See Tab for specific classification standards (Tab. 2) The classification was performed using the natural breaks (Jenks) method.

Table 2 Tourism suitability evaluation grading indicators

Evaluation index	Classification condition				
	5 (high suitability)	4 (higher suitability)	3 (moderate)	2 (lower suitable)	1 (low suitability)
Elevation / m	741-1550	1550-1742	1742-1925	1925-2176	2176-2844
Slope / °	0-2	2-6	6-15	15-25	> 25
Aspect of slope	Flat ground, due south	Southeast, southwest	Due east, due west	Northeast, northwest	due north

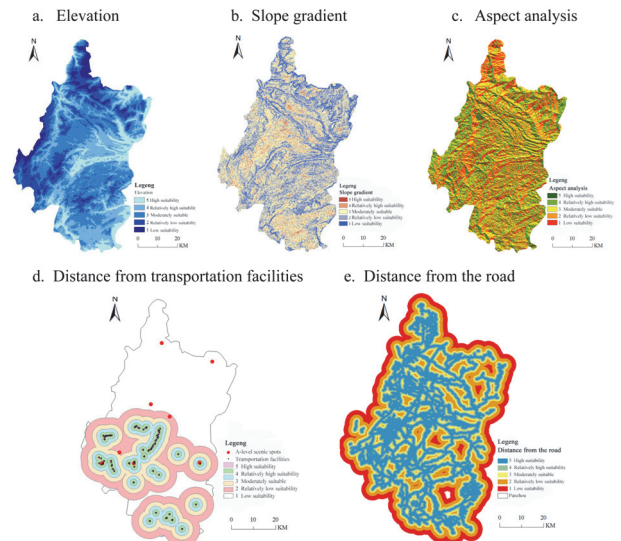


Figure 3 Panzhou City tourism suitability evaluation map

3 RESULTS AND ANALYSIS

3.1 Tourism Suitability Evaluation

Through the calculation of tourism suitability evaluation model based on GIS, the tourism suitability of Panzhou City is divided into five grades, and the tourism suitability zoning map is generated, which intuitively presents the suitability differences in different regions [29].

Highly suitable areas are mainly distributed in some towns in the middle of Panzhou City, such as the areas around Lianghe Street and Hanlin Street, as well as the core zones of Wumeng Prairie and Tuole Ancient Ginkgo Scenic Spot. The natural landscape in these areas is unique and of high quality. The vast grassland and magnificent sea of clouds in Wumeng Prairie and the golden Millennium Ginkgo Forest in Tuole Ancient Ginkgo are very attractive. Convenient transportation, close to the entrance and exit of expressway and main traffic trunk lines, tourists can arrive quickly. Tourism service facilities are relatively perfect, and surrounding hotels and dining places are dense, which can meet the diverse needs of tourists. With good ecological environment, high forest coverage and low ecological sensitivity, it is suitable for large-scale tourism development and high-intensity tourism activities. It is the core bearing area of tourism development in Panzhou City. In the future, it can focus on the layout of high-end resort hotels and characteristic theme homestays, upgrade the level of tourism reception, and develop high-end tourism products such as deep cultural experience and ecological health care [30].

The higher suitable areas are distributed around the highly suitable areas, covering some scenic spots and towns along the main traffic lines. For example, in some areas of Zhuhai Town except the core scenic spot, there is

a certain scale of bamboo forest landscape extension, which is integrated with the surrounding rural life scenes, and the folk culture atmosphere is getting stronger. Although the traffic is a little far away from the main hub, the highway accessibility is good. Tourism facilities have a certain foundation, and there are a considerable number of homestays and farmhouses. This area is suitable for undertaking the diversion of tourists in core scenic spots, developing leisure agricultural tourism, developing farming experience, rural food tour and other projects, relying on local characteristic agricultural products, developing accompanying gifts and other tourism commodities, and expanding the tourism industry chain [31].

Generally, the suitable areas are mostly located in mountainous towns in the east and south of Panzhou City. These areas have relatively complex terrain, large elevation drop, steep slope and high transportation construction cost. For example, some remote mountain villages in Baotian Town have some natural landscapes, but they are difficult to develop. Tourism resources are scattered and lack the integration of high-grade tourism resources. Infrastructure is weak, stability of water and electricity supply is poor and environmental sanitation facilities are insufficient. In the short term, it is suitable for small-scale and low-intensity ecological adventure tours and folk culture exploration tours. On the premise of protecting the ecological environment, traffic conditions should be moderately improved, folk culture resources such as ancient folk handicrafts and traditional sacrificial customs should be excavated and sorted out, and minority tourist routes should be developed [32].

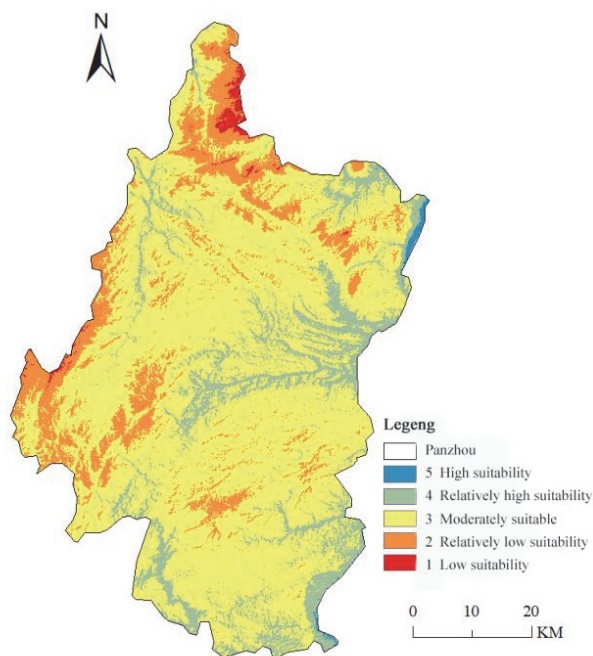


Figure 4 Comprehensive suitability

The low suitable areas are mainly concentrated in the areas with serious rocky desertification in the north of Panzhou City and the buffer zone of some ecological protection areas, such as the sections near karst rocky desertification mountainous areas in Mudi Township. The ecological environment here is fragile, the vegetation

coverage is low, the soil erosion is serious, and the task of ecological restoration is arduous, rugged terrain, inconvenient transportation and poor accessibility. Tourism development is easy to cause irreversible damage to ecology, so ecological protection should be given priority, ecological restoration projects should be implemented, drought-tolerant and barren vegetation should be planted, and interference from human activities should be reduced. On the basis of ecological improvement, ecological science education tours can be explored to show tourists ecological protection achievements and rocky desertification control knowledge (Fig. 4), [33].

Generally speaking, the tourism suitability of Panzhou City presents a pattern of lower in the north and higher in the south, high suitability in core scenic areas and low in remote mountainous areas, which is closely related to the natural environment, resource distribution and social and economic development level. The follow-up tourism planning should adapt to local conditions and develop differently according to this pattern, so as to achieve coordination and win-win among tourism, ecology and economy.

3.2 GAP Analysis

With the help of GIS spatial analysis function, the distribution map of tourism resources and the current situation map of development and construction are superimposed to visually present the development and utilization degree of tourism resources in Panzhou City. At present, the tourism development in Panzhou presents an unbalanced situation. In areas with convenient transportation and close to cities, such as around Lianghe Street, the development of tourism resources is relatively mature: Wumeng Prairie and Tuole Ancient Ginkgo Scenic Spot enjoy high popularity, perfect supporting facilities, considerable annual tourist reception, steady growth of tourism income, dense hotels and homestays around the scenic spot, abundant restaurants and shopping places, and initial formation of tourism industry chain. However, some tourism resources in remote mountainous areas, such as some characteristic ancient villages and niche natural landscapes, are of good quality, but due to inconvenient transportation, lack of publicity and low development level, they are in a state of low development level and insufficient popularity, with few tourists visiting and lack of tourism service facilities (Fig. 5), [34].

In the aspect of potential analysis, the multi-factor superposition and spatial statistical functions of GIS are used to comprehensively consider the potential influencing factors such as natural environment and social economy, and tap the potential areas of tourism development [35]. From the perspective of natural environment potential, Panzhou's vast forest resources, undeveloped mountain canyons and other areas have great potential for developing eco-tourism and outdoor sports tourism. For example, around Niangniangshan National Wetland Park, the ecological environment is excellent. Through GIS analysis of its ecological carrying capacity and landscape uniqueness, combined with the growth trend of market demand for eco-health tourism, high-end health resorts and ecological science research bases can be planned. At the level of social and economic potential, with the sustained

economic development of Panzhou City, the increase of residents' income, the enhancement of tourism consumption capacity, and the further optimization of external transportation, such as the encryption of high-speed rail network and the extension of expressways, the original traffic disadvantaged areas are expected to usher in the opportunity of tourism development. Some towns and villages located within the radiation range of traffic trunk lines can tap folk culture, characteristic agriculture and other resources, develop rural tourism and farming experience tourism products, and undertake the weekend and short-distance travel needs of urban tourists. According to different potential areas, development strategies should be formulated according to local conditions, resources should be accurately invested, and the coordinated development of tourism in Panzhou City should be promoted.

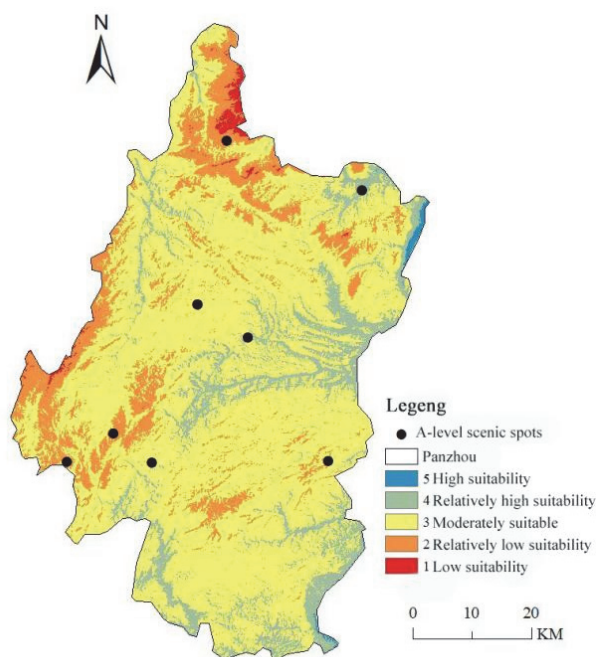


Figure 5 Existing scenic spots

When analyzing the potential, the model of tourism development potential is constructed, assuming that the index of natural environment potential is and the weight is. If the social and economic potential index is constructed, and the weight is, the tourism development potential is $X_1, X_2, \dots, X_a w_1, w_2, \dots, w_a Y_1, Y_2, \dots, Y_b v_1, v_2, \dots, v_b$

$$P = \sum_{i=1}^a w_i x_i + \sum_{j=1}^b v_j Y_j \tag{2}$$

In terms of transportation facilities layout, Panzhou City has Shanghai-Kunming high-speed railway, Shanghai-Kunming expressway and other traffic trunk lines running through it, but there are shortcomings in branch traffic in some scenic spots (Figs. 6 and 7). Taking Wumeng Prairie as an example, although the internal roads of the scenic spot can meet the basic traffic, during the tourist season the road section from the high-speed exit to the entrance of the scenic spot is prone to congestion, the road capacity is difficult to cope with the instantaneous

peak passenger flow, and some road signs are unclear, causing trouble to self-driving tourists. The coverage of public transportation lines is insufficient. Some remote scenic spots, such as some niche ancient village scenic spots, only have a small number of regular fixed-point buses, which are not conducive to individual travel, limit the number of tourists visiting, and form a gap with tourists' convenient travel needs. In the follow-up, it is necessary to optimize road design, increase traffic signs, encrypt bus frequency and improve transportation transfer system.

When evaluating the layout of tourism transportation facilities in Panzhou City, accessibility index is very important to measure the convenience of tourists from the departure place to the scenic spot. Taking Panzhou City (departure place i) and four main scenic spots (Wumeng Prairie, Tuole Ancient Ginkgo biloba, Dadong Bamboo Sea and Niangniang Mountain) as research objects, the accessibility formula based on time distance is as follows:

$$A_{ij} = \frac{T_{ij}}{\sum_{j=1}^n T_{ij}} \tag{3}$$

Among them, A_{ij} means accessibility from the departure place to the scenic spot. The larger the value, the more convenient it is to get to the scenic spot j from the departure place i , that is, tourists can reach the scenic spot j more quickly and easily.

T_{ij} represents the shortest transit time from departure place i to scenic spot j . This index comprehensively considers the influence of road conditions, transportation modes, transfer times and other factors on transit time. For example, if there is a direct expressway between the departure place i and the scenic spot j and the traffic volume is small, the value is relatively small. On the contrary, if the road is narrow, the traffic is congested or multiple transfers are needed, the value of T_{ij} will be larger.

n represents the number of destination scenic spots. Through the comprehensive calculation of the transit time from the departure place i to all scenic spots j , the accessibility relationship between the departure place i and all scenic spots j can be comprehensively reflected, thus evaluating the rationality and convenience of the transportation facilities layout more accurately.

Through this formula, we can quantify the accessibility from different departure places i to various scenic spots j , and provide scientific basis for optimizing the layout of tourism transportation facilities and improving tourists' travel experience in Panzhou City. For example, if the calculation results show that the accessibility of some scenic spots is low, the traffic connection between these scenic spots and the main departure places can be strengthened, such as building new roads and optimizing bus lines, so as to improve the convenience of the overall tourism traffic.

Accommodation facilities are unevenly distributed. In Lianghe Street, Hanlin Street and other urban areas, as well as around Wumeng Prairie and Tuole Ancient Ginkgo Scenic Area, high, middle and low-grade hotels and homestays gather, and accommodation choices are diverse, which can meet the needs of tourists at different consumption levels. However, in remote mountainous

villages and towns, accommodation resources are scarce, conditions are poor, and the number of beds is small. For example, near the folk culture experience points in some mountainous areas, only a small number of farmers are self-operated farmhouses, and the reception capacity is limited. The accommodation environment and sanitation facilities are difficult to meet the standards, and it is difficult to undertake group tourists, which affects tourists' deep experience of folk customs. According to the distribution of tourism resources, the balanced layout of accommodation facilities should be reasonably guided to improve the reception capacity in remote areas.

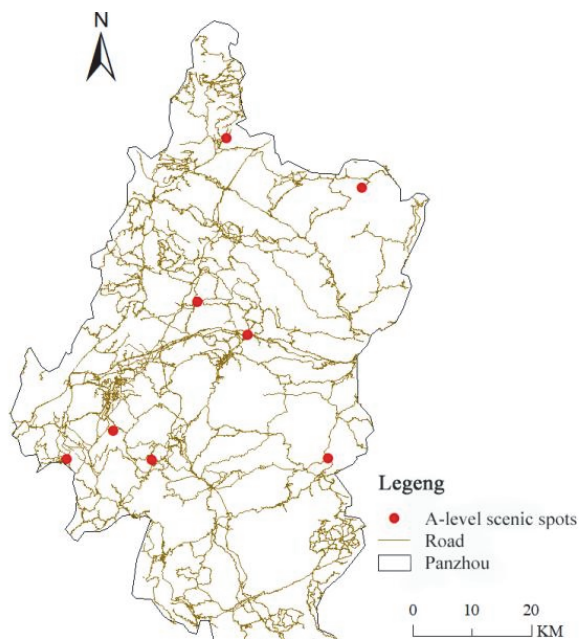


Figure 6 Scenic spots and roads

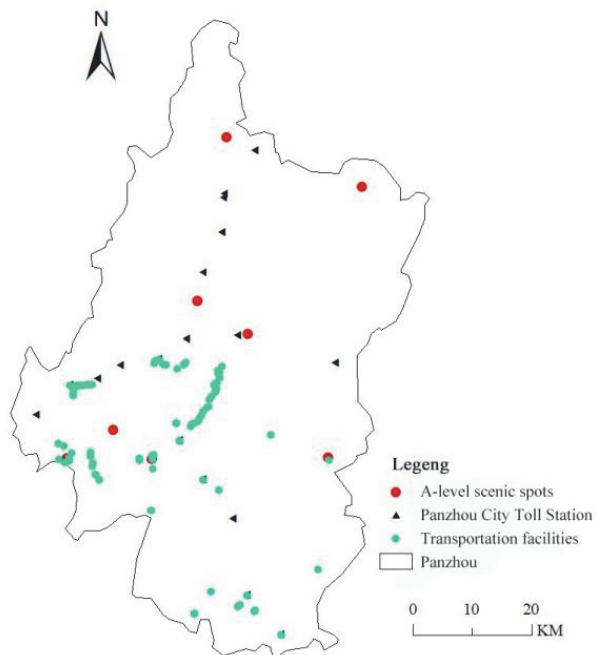


Figure 7 Scenic spots and transportation facilities

Catering facilities also have layout problems. The dining places around the urban area and popular scenic spots are dense, but the homogenization is serious. Most of them are common home-cooked restaurants and food stalls.

The local specialty dishes are not deeply excavated, and there is a lack of high-end catering brands that can show the unique food culture of Panzhou. It is difficult to meet the needs of tourists to try early and experience special food. In remote areas, there are few and scattered restaurants, the supply of food materials is unstable, and it is difficult to guarantee food hygiene. For example, along some eco-tourism adventure routes, food supply is difficult, which affects tourists' itinerary. It is necessary to cultivate special food, strengthen health supervision, optimize food layout and ensure tourists' food experience.

In the analysis of socio-economic potential index, there is a significant correlation between residential distribution and tourism suitability. As shown in Fig. 8, the tourism suitability level is generally high in the areas with high nuclear density of residential areas around A-level scenic spots in Panzhou City. High-suitability areas are mostly concentrated around towns with dense residential areas and the core areas of scenic spots, such as Lianghe Street and Hanlin Street. Because of the large population density and proximity to the town center, it can not only provide sufficient labor and consumer markets for tourism development, but also share urban infrastructure and reduce development costs. However, in remote mountainous areas, the residential areas are sparse and the tourism suitability level is low, which reflects the direct impact of residential areas distribution on the layout of tourism service facilities and market potential.

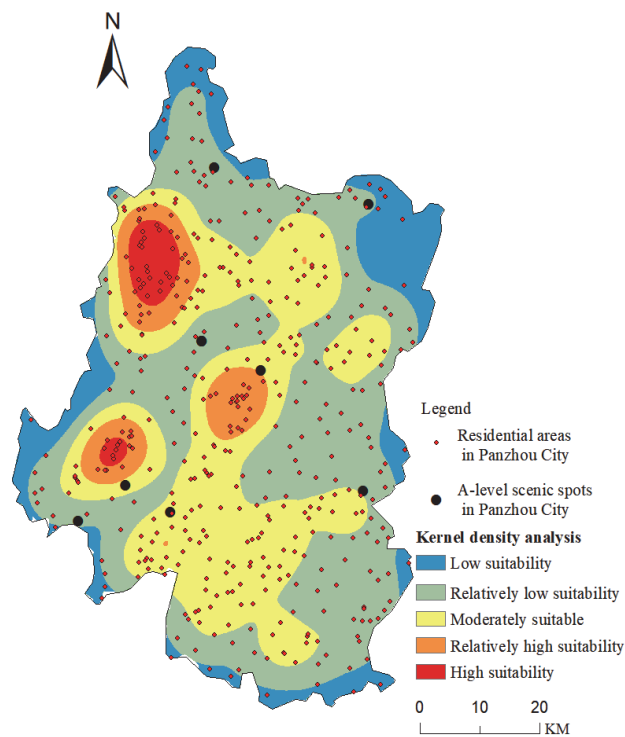


Figure 8 Residential kernel density

The influence of distance from water source in ecological sensitivity on tourism suitability can be further confirmed by the spatial correlation between water system distribution and suitability grade. As shown in Figure (Fig. 9), the A-level scenic spots in Panzhou City are mostly distributed along the main water system or close to the water source, in which the high suitable areas are concentrated within 5-10 kilometers from the water source.

This area is convenient to obtain water resources to ensure the operation of tourism facilities, and maintains ecological stability due to controllable development intensity. Areas too close to the water source (such as within 1 km) need to strictly protect the water source, and the suitability level is mostly low. However, in the northern mountainous areas far away from the water source, the suitability level is generally low because of the high water supply cost and fragile ecology.

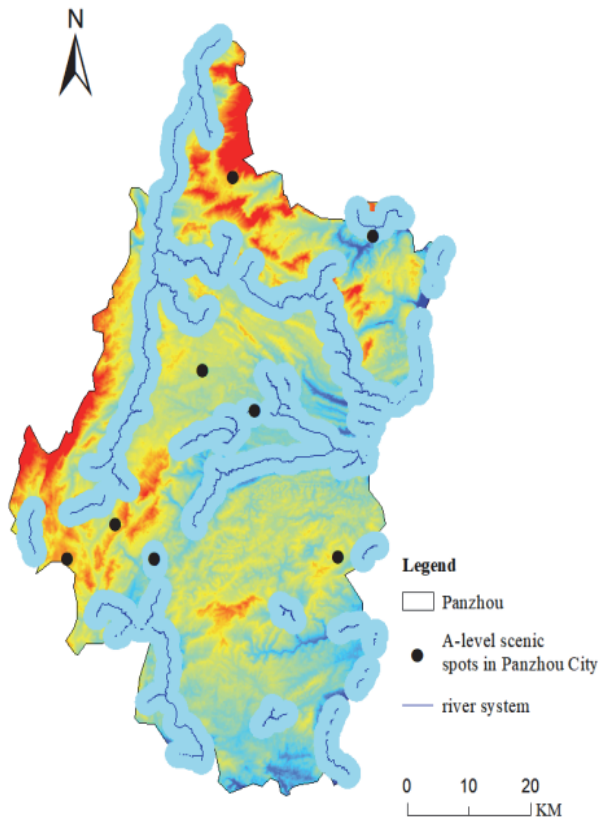


Figure 9 The distance between the scenic spot and the water source

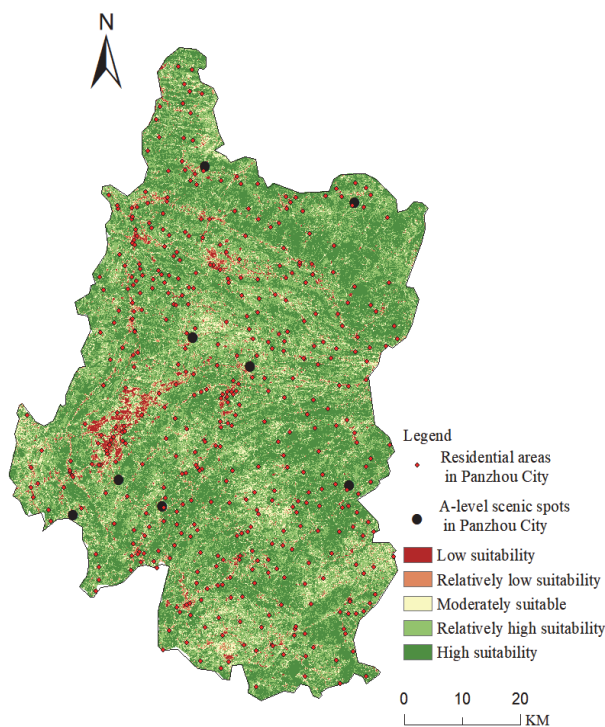


Figure 10 Vegetation coverage kernel density

As the core index of ecological sensitivity, the spatial distribution of vegetation coverage is positively correlated with the level of tourism suitability. As shown in Figure (Fig. 10), the vegetation coverage of highly suitable areas such as Wumeng Prairie and Tuole Ancient Ginkgo Scenic Area is over 60%, and the ecosystem is stable, which can provide tourists with high-quality ecological experience. High suitable areas, such as around Zhuhai Town, are densely covered with bamboo forests. Although the vegetation coverage is slightly lower than that of the core scenic spots, the ecological sensitivity is still low, which is suitable for ecological leisure activities. However, in the northern rocky desertification region, the vegetation coverage is less than 30%, the ecological fragility is high, and the tourism suitability level is low, which further verifies the constraint effect of vegetation coverage on tourism development.

4 DISCUSSION

According to the evaluation results of tourism suitability, Panzhou City should adopt the strategy of zoning development. In highly suitable areas, such as Wumeng Prairie and the core area of Tuole Ancient Ginkgo Scenic Area, increase the development of high-end tourism products. Wumeng Prairie can build a comprehensive resort integrating grassland sightseeing, folk experience and ecological health care, and build high-end resort hotels and starry sky campsites, and support them with special projects such as equestrian performances and grassland music festivals to extend the stay time of tourists. Around the ancient Ginkgo landscape, Tuole Ancient Ginkgo Scenic Spot develops Ginkgo Culture Theme B&B, Ginkgo Health Catering, and holds Ginkgo Photography Contest, Golden Autumn Ginkgo Festival and other activities to enhance the cultural connotation and attraction of the scenic spot.

As a tourism expansion area, the higher suitable area should strengthen the linkage with the core scenic spots. Zhuhai Town can rely on Dadong Bamboo Sea Scenic Area to develop bamboo culture eco-tourism, create a bamboo art production experience workshop, and launch manual courses such as bamboo weaving and bamboo carving, so that visitors can personally feel the charm of traditional bamboo art; build bamboo trails and bicycle greenways, connect surrounding villages in series, carry out rural cycling and farming experience tours, realize the integration of tourism resources, enrich the supply of tourism products, and undertake the diversion of tourists in core scenic spots.

For general suitable areas, in view of their ecological environment and resource characteristics, ecological protection should be taken as the premise, and niche tourism products should be moderately developed. In mountainous towns such as Baotian Town, excavate local folk culture and traditional farming culture, develop folk exploration tours and farming research tours, organize tourists to visit ancient residential buildings, display traditional farm tools, and participate in farming activities such as rice transplanting and fruit picking, so that tourists can feel the original rural life, and at the same time strengthen ecological monitoring and protection to ensure that tourism activities do not damage the ecology.

In the aspect of route optimization, using GIS network analysis function, combined with scenic spot distribution and traffic conditions, diversified tourist routes are designed [36]. Create a "natural scenery tour" route, connecting scenic spots such as Wumeng Prairie, Dadong Bamboo Sea and Niangniangshan Wetland Park, so that visitors can appreciate the beauty of Panzhou City. The "Cultural Experience Tour" route runs through the Panxian Conference site, PanxianDadong, Yi Torch Festival, etc., so that visitors can deeply understand the history, culture and folk customs of Panzhou City. In addition, special tourist routes, such as parent-child popular science tours and outdoor hiking adventure tours, are designed for different groups such as parent-child families and outdoor adventure enthusiasts to meet diversified market demands and enhance tourists' travel experience. In view of the traffic shortcomings in the northern rocky desertification area identified by GAP analysis, it is suggested to give priority to the construction of the connecting highway from Mudi Township to Wumeng Prairie Scenic Area, and improve the road marking system simultaneously.

According to the correlation characteristics between residential distribution and tourism suitability, "residential-scenic spot" coordination should be strengthened in the optimization of tourism facilities layout. In the residential areas around towns in highly suitable areas, residents can be guided to participate in tourism management and develop characteristic homestays and farmhouses. For example, the residential areas around the ancient ginkgo scenic spot in Tule can rely on ancient ginkgo resources to create a "ginkgo theme homestay cluster", which not only improves reception capacity but also retains local customs. For the low suitable areas with sparse residential areas in remote mountainous areas, the resident population can be moderately concentrated by "moving villages and merging points", and small tourist service stations can be built to solve the problem of tourists' supply on the way.

Combined with the distribution characteristics of water system, tourism development needs to balance water resources utilization and ecological protection. In a higher suitable area 5-10 kilometers away from the water source, waterfront leisure projects can be developed, such as the water system around Niangniang Mountain Scenic Area, and eco-tourism products such as bamboo rafting and wetland bird watching can be created. Strictly limit the construction activities within 1km from the water source, keep only ecological monitoring facilities, maintain the water quality of the water source by setting up ecological buffer zones, and avoid the threat of tourism development to drinking water safety.

According to the spatial difference of vegetation coverage, differentiated ecological protection strategies should be implemented. The core scenic spots with high vegetation coverage need to control the daily reception volume and adopt the "reservation system" to avoid ecological overload. For example, the Wumeng Prairie can designate an ecological conservation area and prohibit motor vehicles from entering. Ecological restoration should be given priority in the low vegetation coverage areas in the north, and drought-tolerant plants such as *Pinus yunnanensis* and *Zanthoxylumbungeanum* should be planted. After the vegetation coverage is increased to over 40%, ecological popular science tourism should be

moderately developed, such as building an exhibition hall for rocky desertification control to display vegetation restoration technologies and achievements.

Product diversification strategy aims to expand the tourism industry chain. On the one hand, dig deep into the characteristic culture and natural resources of Panzhou City, and develop characteristic tourism products, such as designing ginkgo leaf bookmarks and ginkgo fruit health products with ancient ginkgo as elements, and making national costumes and handicrafts inspired by Yi culture to increase tourism shopping income. On the other hand, strengthen the integration of tourism with agriculture, sports, health care and other industries, and develop new formats of rural tourism, sports tourism and health care tourism. Niangniangshan National Wetland Park can rely on a good ecological environment to build a healthy holiday base and provide services such as hot spring recuperation, forest yoga and Chinese medicine health care. Organize mountain marathon, grassland cycling and other sports events, attract sports enthusiasts to participate, build sports tourism brands, and enhance the tourism competitiveness of Panzhou City in all directions. In addition, the product diversification strategy needs to incorporate smart tourism elements, such as piloting the "AR Ginkgo Culture Guide System" in Tuole Ancient Ginkgo Scenic Area to enhance tourists' experience. In view of the areas with high ecological sensitivity, it is suggested to develop a "low-interference ecological research route".

In view of the gap between the development of tourism resources and market demand, Panzhou should strengthen the protection and integration of tourism resources. On the one hand, for high-quality resources that have not been developed or have a low degree of development, such as some remote mountainous areas with unique ecological landscapes and ancient villages with profound folk culture, establish a strict protection mechanism, delimit the scope of protection, and formulate protection plans to prevent damage caused by over-exploitation. On the other hand, we should integrate scattered tourism resources, take core scenic spots such as Wumeng Prairie and Tuole Ancient Ginkgo Scenic Spot as the leader, and combine the surrounding characteristic scenic spots to create a comprehensive tourism area, so as to realize resource sharing, mutual exchange of tourists and enhance the overall attractiveness. For example, the Jiaoziding and Niangniangshan National Wetland Park around Wumeng Prairie are connected in series, and the "Grassland-Mountain-Wetland" eco-tourism loop is launched to enrich tourists' experience.

In terms of upgrading tourism service facilities, optimize the transportation network layout, increase investment in the construction of branch roads in scenic spots, broaden and transform congested road sections, and improve the road identification system to ensure the smooth passage of tourists. Increase public transport lines and frequency, especially special lines leading to remote scenic spots, strengthen the connection with urban public transport and railway passenger transport, and build a convenient transfer system. In the construction of accommodation facilities, according to the tourism suitability zoning, we should guide funds to invest in areas where accommodation resources are scarce, develop

characteristic homestays and country inns, and improve accommodation quality and hygiene standards while maintaining local characteristics to meet the needs of different tourists. The optimization of catering facilities pays attention to excavating local food culture, cultivating characteristic catering brands, encouraging the opening of restaurants displaying Panzhou characteristic catering in scenic spots and towns, such as innovative dishes with Panzhou ham, Rosa roxburghii and other specialties as ingredients, and strengthening catering hygiene supervision to ensure tourists' healthy diet, make up the gap in all directions, and promote the high-quality development of tourism in Panzhou.

5 CONCLUSION

The innovations of this study are as follows: 1. It is the first time to apply GIS tourism suitability evaluation and GAP analysis system to Panzhou City to provide regional cases for tourism development in karst mountainous areas; 2. GAP analysis combined with accessibility quantitative results can accurately locate and develop "blank areas".

Although some achievements have been made in this study, there are still limitations. In terms of data, the accuracy of some indicator data needs to be improved. For example, ecological environment data mostly comes from remote sensing interpretation and statistical data, and there are few field monitoring data, which makes it difficult to accurately reflect micro-ecological changes. Tourism market demand data is limited by questionnaire samples and survey time, so it is difficult to reflect market fluctuations in time because the potential demand of tourists is not deeply excavated and the dynamic update lags behind. In the selection of indicators, the emerging tourism forms are not considered enough. For example, there are few exclusive indicators for research tourism and health tourism, which are not fully integrated into smart tourism elements and are difficult to adapt to the development of new tourism formats. The correlation between some indicators is complex and there is interaction, and the evaluation system is inadequate in addressing their coupling effects, which affects the evaluation accuracy. In the application of the method, GIS spatial analysis focuses on static pattern, and lacks dynamic simulation of tourism development, so it is difficult to predict the long-term effect under different planning strategies. In the evaluation model, the subjectivity of expert scoring is difficult to eliminate. Although it has been tested by consistency, it may still deviate from objective reality. The membership degree of fuzzy comprehensive evaluation is relatively general, and the standard needs to be refined [37].

Follow-up research can break through from multiple directions: data acquisition integrates multi-source monitoring, strengthens the construction of ecological field monitoring station network, and combines the Internet of Things and low-elevation remote sensing of drones to collect ecological data in real time. Expand the cooperation of tourism big data platform, dig deep into online travel reviews, search heat and other information, accurately grasp market dynamics, and realize high-frequency data update. Indicator optimization closely follows the tourism trend, incorporates the characteristic indicators of emerging formats, and refines indicators such as the

coverage rate of smart tourism facilities and the richness of research courses. Using structural equation modeling and other methods to analyze the complex correlation of indicators, build a coupling and coordination model, and improve the scientific evaluation. Deepen the analysis of the coupling mechanism of "residential area-scenic spot-ecology", for example, optimize the layout of service facilities through the correlation model between residential area density and the utilization rate of tourism facilities. Divide ecological protection zoning based on water system basin, and refine development intensity standards of different distance zones. Establish a dynamic monitoring system of vegetation coverage to provide real-time data support for the adjustment of tourism development intensity.

In addition, emerging indicators such as the coverage rate of smart tourism facilities are not included in the evaluation system, which needs to be improved in the follow-up study: Methods to innovate and strengthen dynamic simulation, introduce system dynamics model, combine GIS to simulate multiple scenarios of tourism development, and predict long-term ecological, economic and social benefits under different strategies. Improve the evaluation model, use machine learning algorithm to mine data rules to determine index weights, reduce subjective interference, refine fuzzy comprehensive evaluation criteria, enhance the reliability of results, and provide stronger support for the high-quality development of tourism in Panzhou City.

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